Atomic Layer Deposition to Enable the Production, Optimization and Protection of Spaceflight Hardware (ALD)

Completed Technology Project (2011 - 2013)

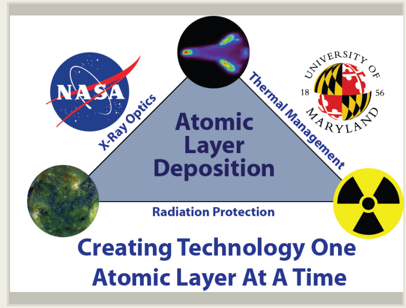
Project Introduction

Atomic Layer Deposition (ALD) a cost effective nano-manufacturing technique allows for the conformal coating of substrates with atomic control in a benign temperature and pressure environment. Through the introduction of paired precursor gases thin films can be deposited on a myriad of substrates ranging from glass, polymers, aerogels, and metals to high aspect ratio geometries thus allowing NASA/GSFC to facilitate the production, optimization and protection of valuable space centric hardware. Novel deposition methods and materials justified the design and installation of a custom reactor where dynamic in situ measurements reduced the formulation of the materials system to prototype at a fraction of the cost. Two specific examples of the reactors benefit include the formation of nanolaminated films and additive material protection. Nanolaminate films constitute diverse materials of periodic layers with distinct film thickness that measure on the order of nanometers. The multilayered structure often imparts unique characteristics to the nanolaminate film where the periodic morphology may have physical properties that are far superior to single or pure material films. Polymers and polymer composite materials used for lightweight spacecraft structural components are susceptible to surface damage by high-energy collisions with atomic oxygen found in low-Earth orbit and by the high fluxes of vacuum ultraviolet radiation. Because these materials are insulators, they also can accumulate significant levels of surface charge. Plasma-enhanced chemical vapor deposition (PECVD) of SiO2 films is effective at protecting polymer materials, but relatively thick PECVD must be used to eliminate pinholes and to assure sufficient film thicknesses over surfaces with significant topography. An investigation of TiO2 and TiN coupled films is underway. While each of these materials alone can provide a protective layer for the polymer, the TiO2 is particularly well suited to VUV protection and the TiN, being conductive, will help dissipate static charge. A tertiary product of metal oxide ALD is its ability to protect polymeric films such as Kapton from AO erosion in low earth orbiting missions.   NASA Glen confirmed this property where samples of Kapton film coated with an ALD of a metal oxide were exposed to AO fluxes equivalent to 10 years resulted in mass conservation of 98%.

The project includes working on the Passive Variable Emittance Film Prototype for thermal control, Iridium Coated X-Ray Optic and Boron Nitride Film. Collaborators: University of Maryland

Anticipated Benefits

N/A



Project Image ROE FY12 CIF 78 CC Atomic Layer Deposition to Enable the Production, Optimization and Protection of Spaceflight Hardware

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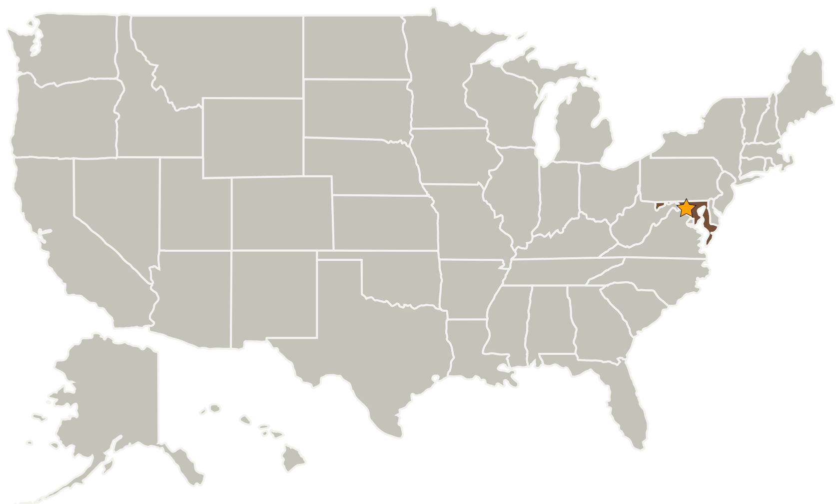
Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
★Goddard Space Flight Center(GSFC)	Lead Organization	NASA Center	Greenbelt, Maryland
University of Maryland-College Park(UMCP)	Supporting Organization	Academia	College Park, Maryland

Primary U.S. Work Locations
Maryland

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Goddard Space Flight Center (GSFC)

Responsible Program:

Center Innovation Fund: GSFC CIF

Project Management

Program Director:

Michael R Lapointe

Program Manager:

Peter M Hughes

Project Manager:

Theodore D Swanson

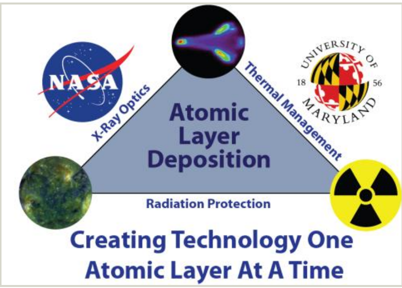
Principal Investigator:

Vivek H Dwivedi

Co-Investigator:

William W Zhang

Images



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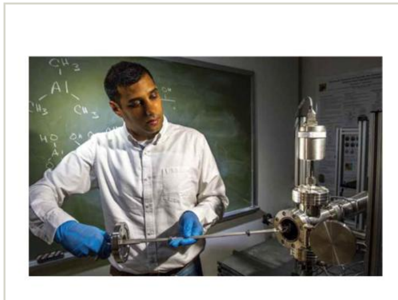
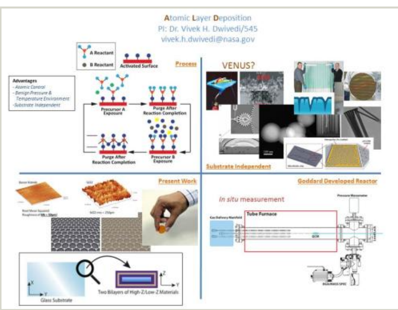
Project Image ROE FY12 CIF 78 CC Atomic Layer Deposition to Enable the Production, Optimization and Protection of Spaceflight Hardware
(https://techport.nasa.gov/image/1268)



ALD_Reactor
Loading of QCM
(https://techport.nasa.gov/image/2583)



Tech_Brief
ALD Capabilities
(https://techport.nasa.gov/image/2582)

Stories

ALD work of Adomaitis, Dwivedi featured in NASA Goddard newsletter
(https://techport.nasa.gov/file/1161)

NASA Connects Down Under for Growth of Carbon Nanotubes
(https://techport.nasa.gov/file/1163)

NASA Engineer Achieves Another Milestone in Emerging Nanotechnology
(https://techport.nasa.gov/file/1162)

Space-Age Materials, One Atomic Layer at a Time
(https://techport.nasa.gov/file/1159)

Technology Maturity (TRL)

Start: **1**
Current: **4**
Estimated End: **4**

1 2 3 4 5 6 7 8 9

Applied Research | Development | Demo & Test

Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  - └─ TX12.1 Materials
    - └─ TX12.1.7 Special Materials

UMD Alumni Article
(https://techport.nasa.gov/file/1158)

Virtual Toothpick Helps Technologist 'Bake' the Perfect Thin-Film Confection
(https://techport.nasa.gov/file/1160)

Project Website:

http://aetd.gsfc.nasa.gov/